Consortium for Advanced Simulation of Light Water Reactors

Progress on Operational Reactor Modeling

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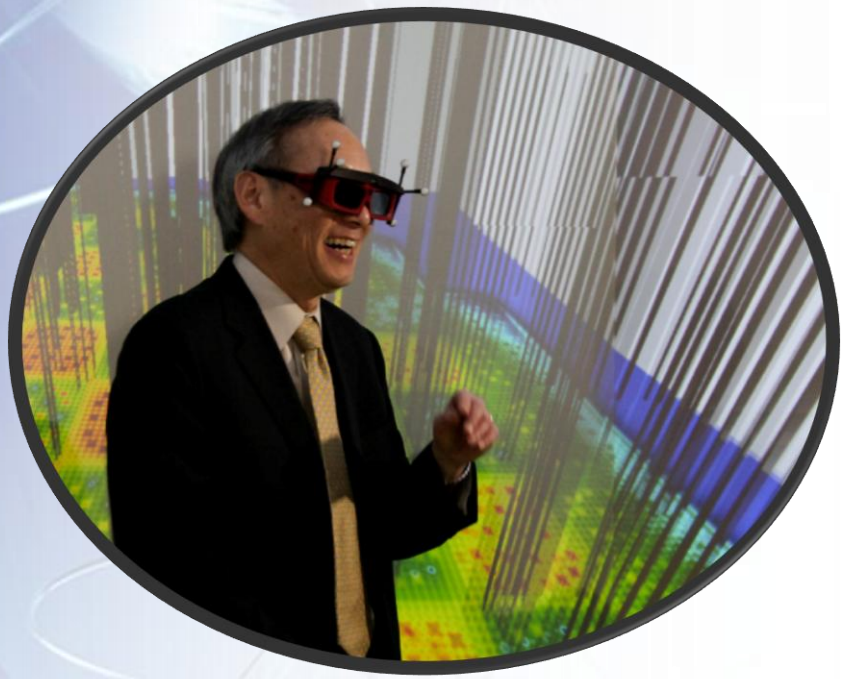
Nuclear Reactor Technologies RD&D Summit
Gaithersburg, MD

March 20, 2012



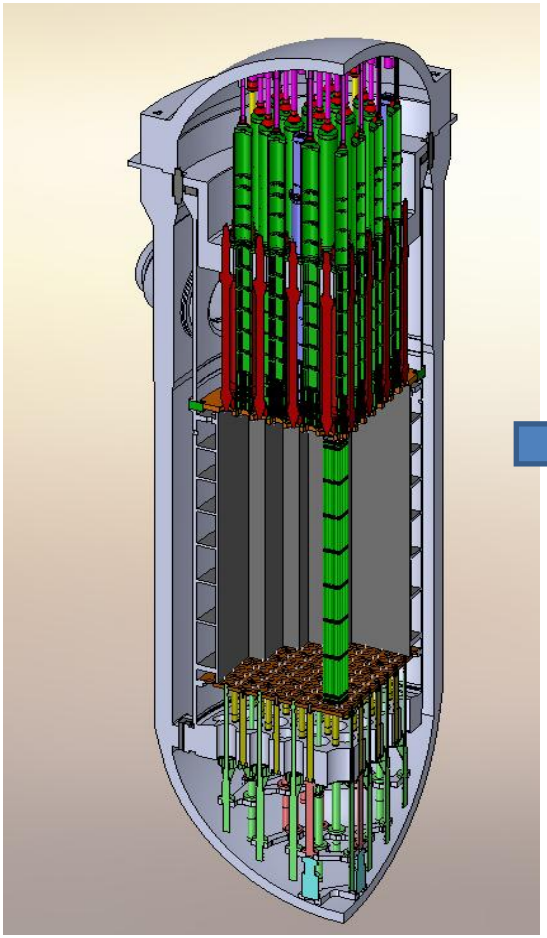
Secretary Chu Visit to CASL HQ, February 2012

U.S. DEPARTMENT OF ENERGY
Nuclear Energy

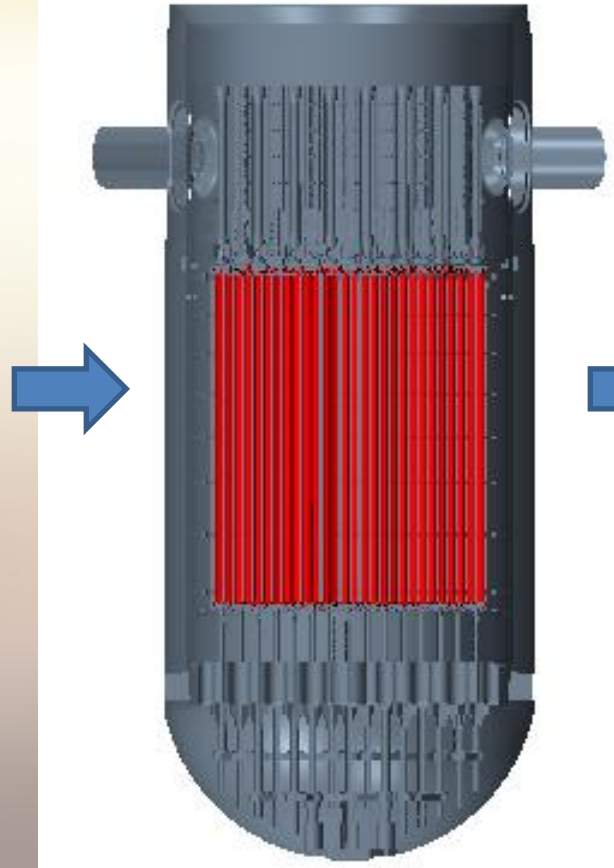
CASL Physical Reactor – Watts Bar Unit 1

- Four-loop Westinghouse Pressurized Water Reactor, 1170 MWe
- Unit 1 operational, Unit 2 under construction
- Unit 1 start up in 1996
- CASL modeling with 3D CFD and Neutronics models

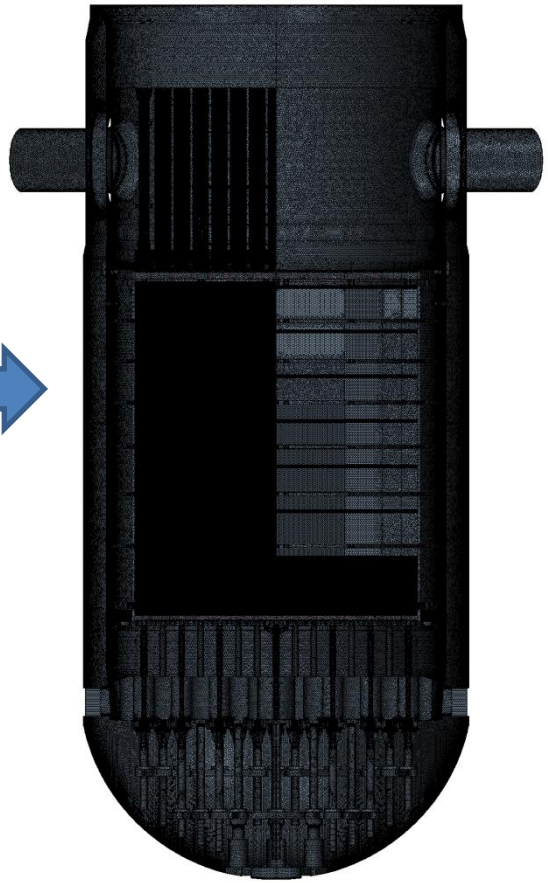
CFD Modeling Geometry & Mesh



CAD Model



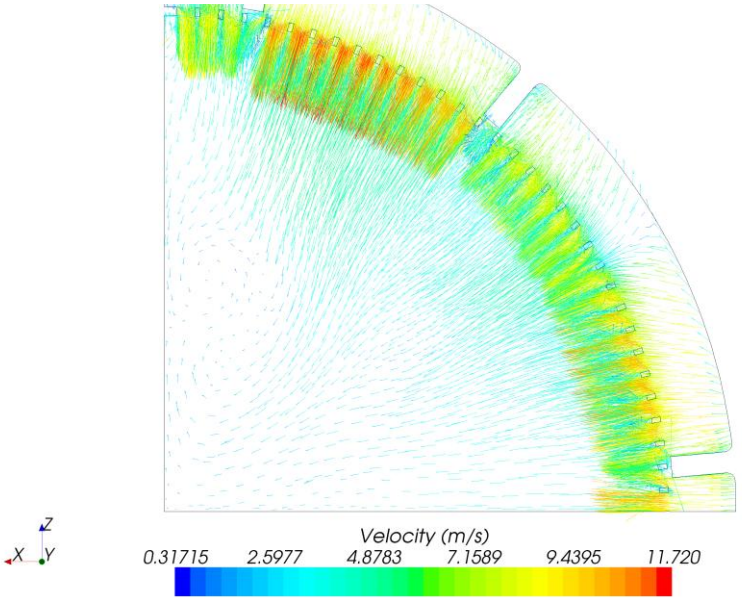
CFD Model

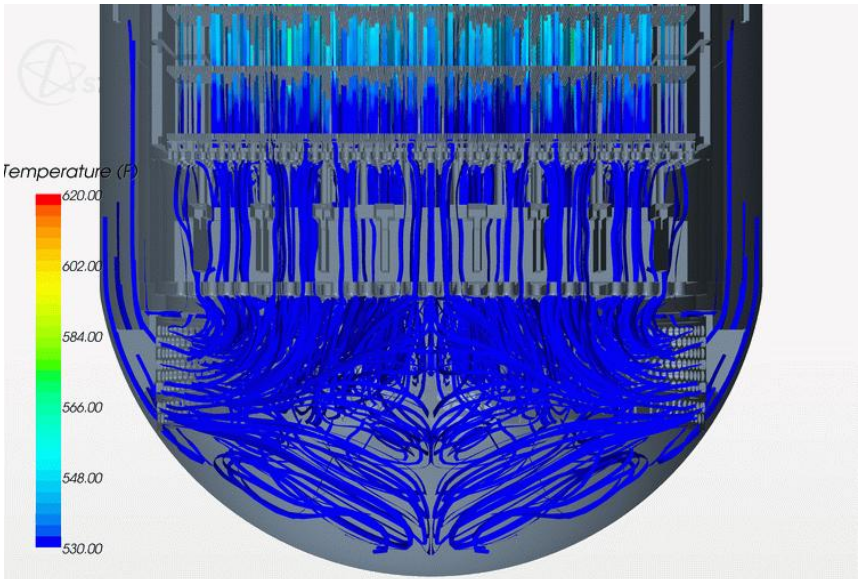


333M cell porous grid model
1 Billion cell detailed grid model

CFD Flow Distribution Results

Flow Distribution Through Flow Skirt





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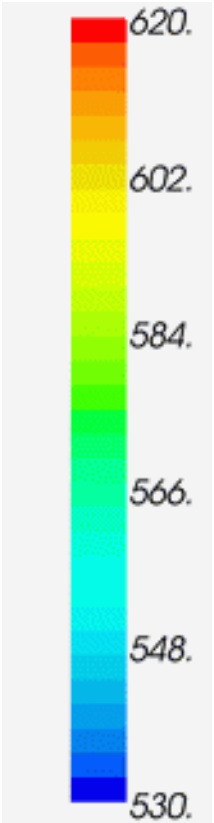
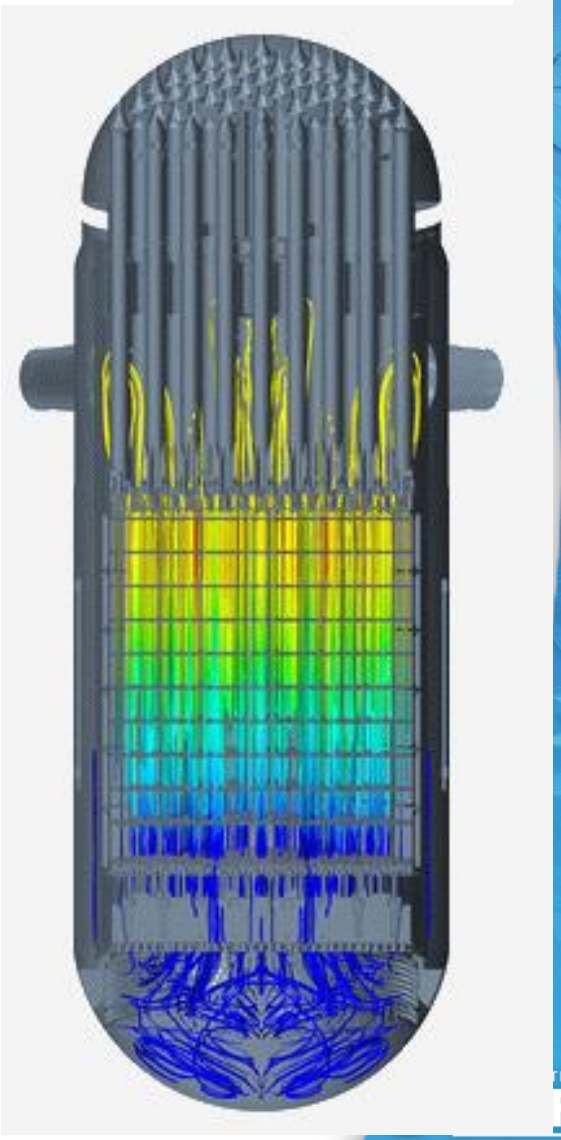
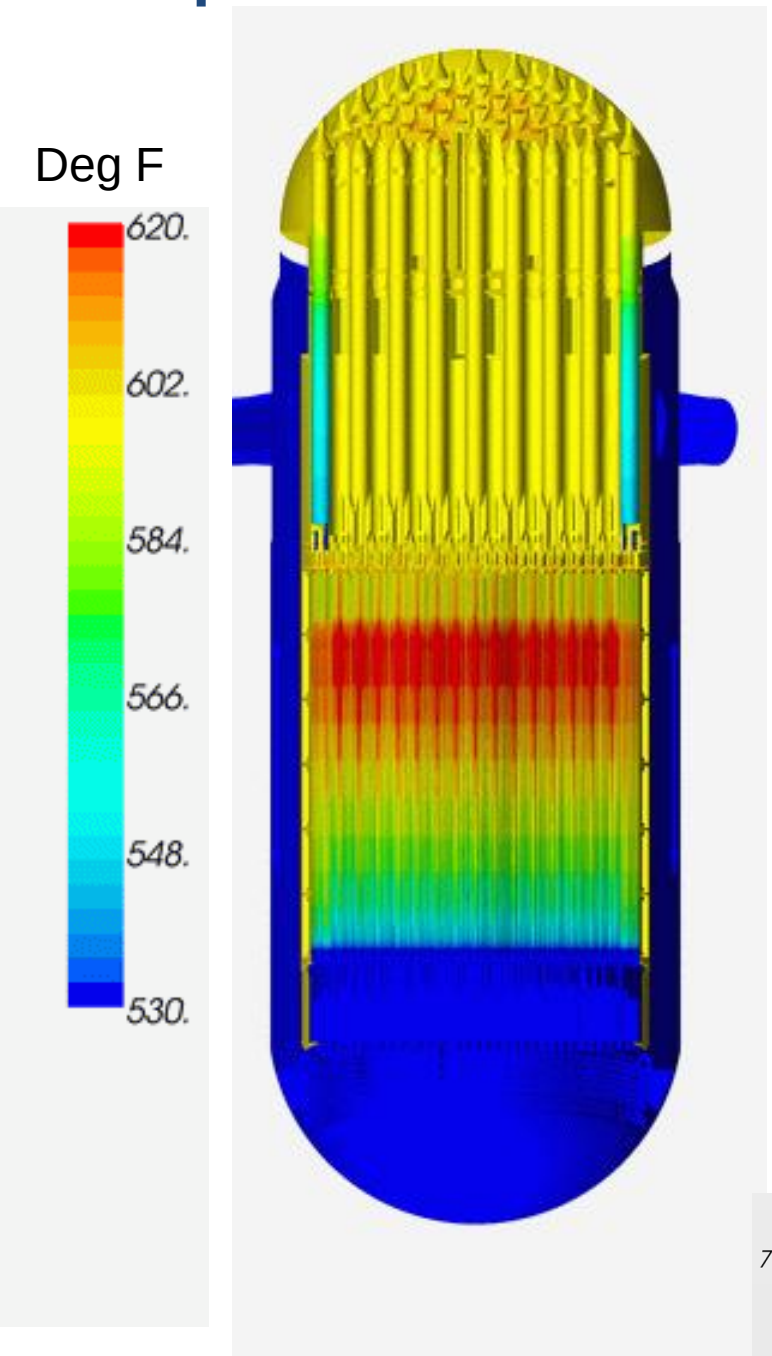
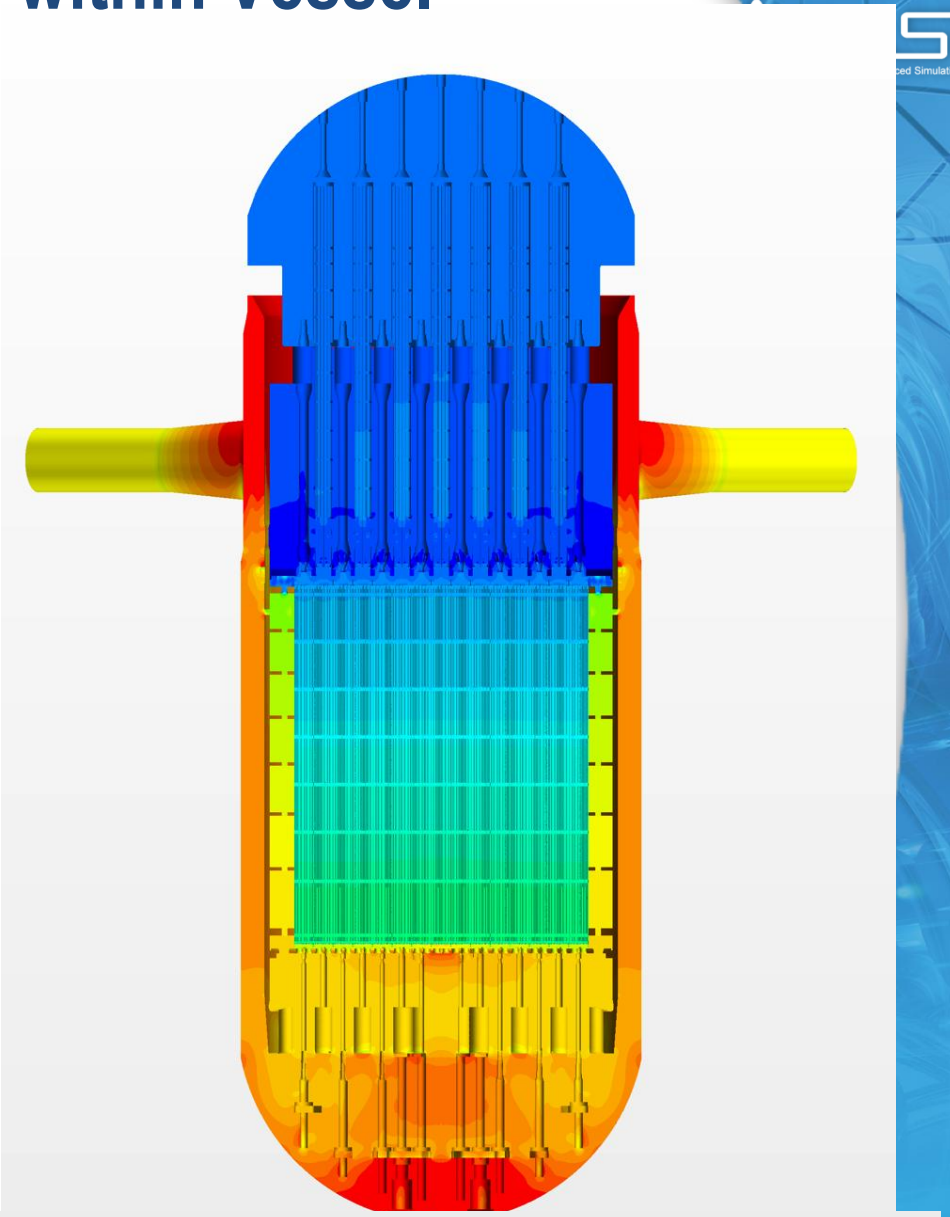


Flow Distribution Through Vessel



Temperature and Pressure within Vessel





Watts Bar Unit 1 Cycle 1 – Neutronics Modeling

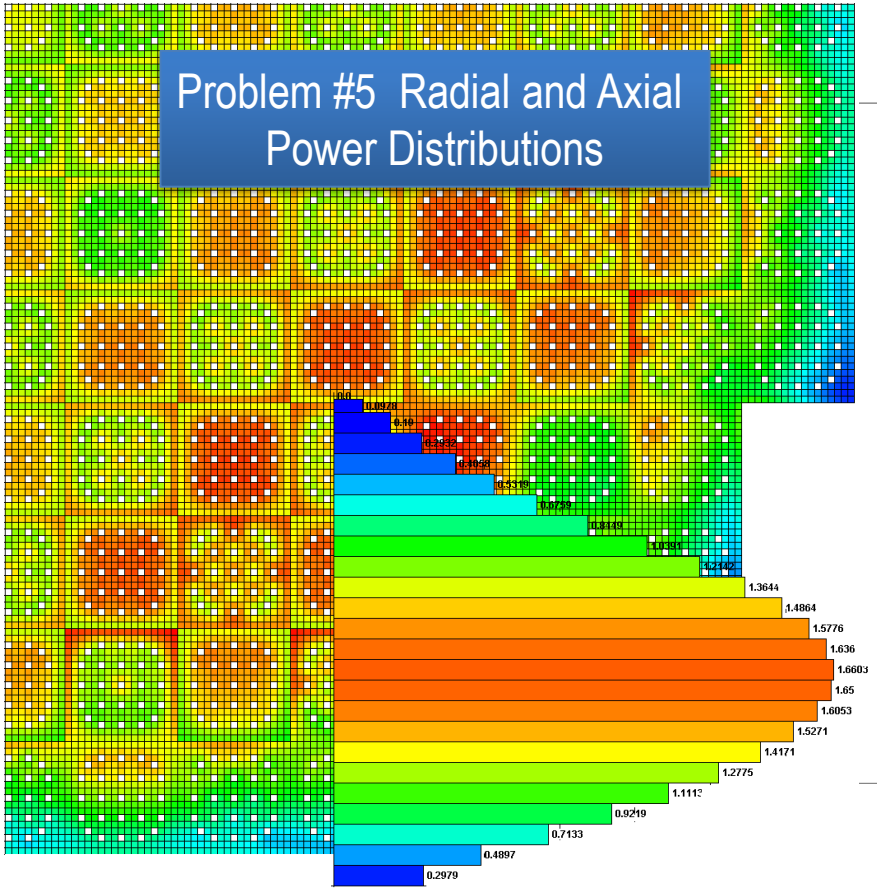
- A set of progression problems developed to guide progress from pin cell modeling to full core with depletion and T/H feedback
- Reference solutions used for problems that do not correspond to reactor conditions/geometries
- Problems #5, #8, #9 correspond to problems with measured plant data
- Models are being developed with existing tools to compare with measured data
- Neutronics methods based on pin-by-pin radiation transport

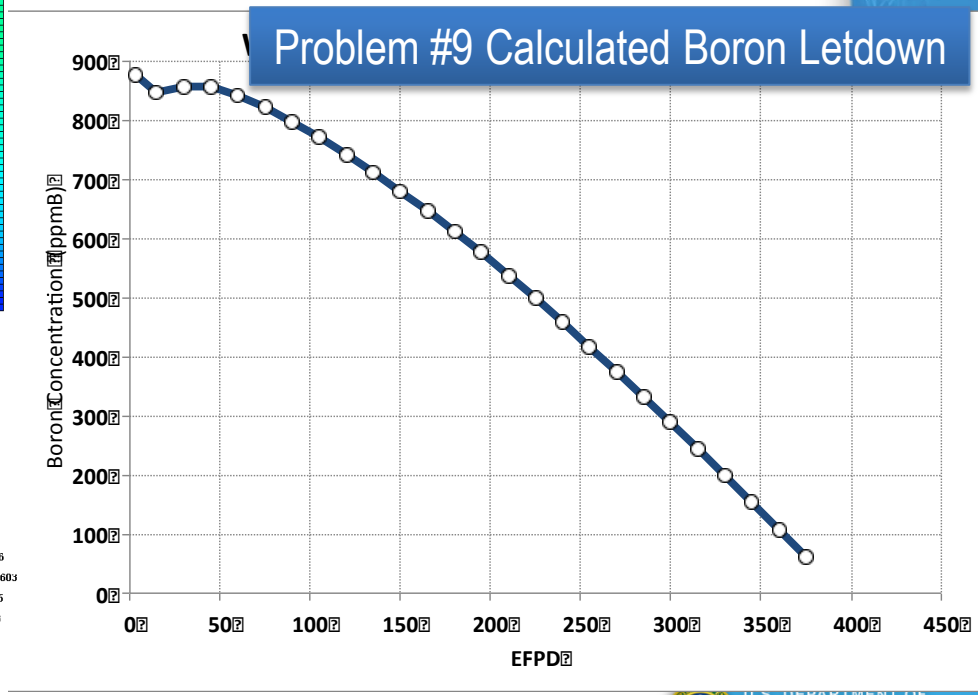
Benchmark Progression Problems

- #1 2D HZP Pin Cell
- #2 2D HZP Lattice
- #3 3D HZP Assembly
- #4 HZP 3x3 Assembly CRD Worth
- **#5 Physical Reactor Zero Power Physics Tests (ZPPT)**
- #6 HFP BOL Assembly
- #7 HFP BOC Physical Reactor w/ Xenon
- **#8 Physical Reactor Startup Flux Maps**
- **#9 Physical Reactor Depletion**
- #10 Physical Reactor Refueling

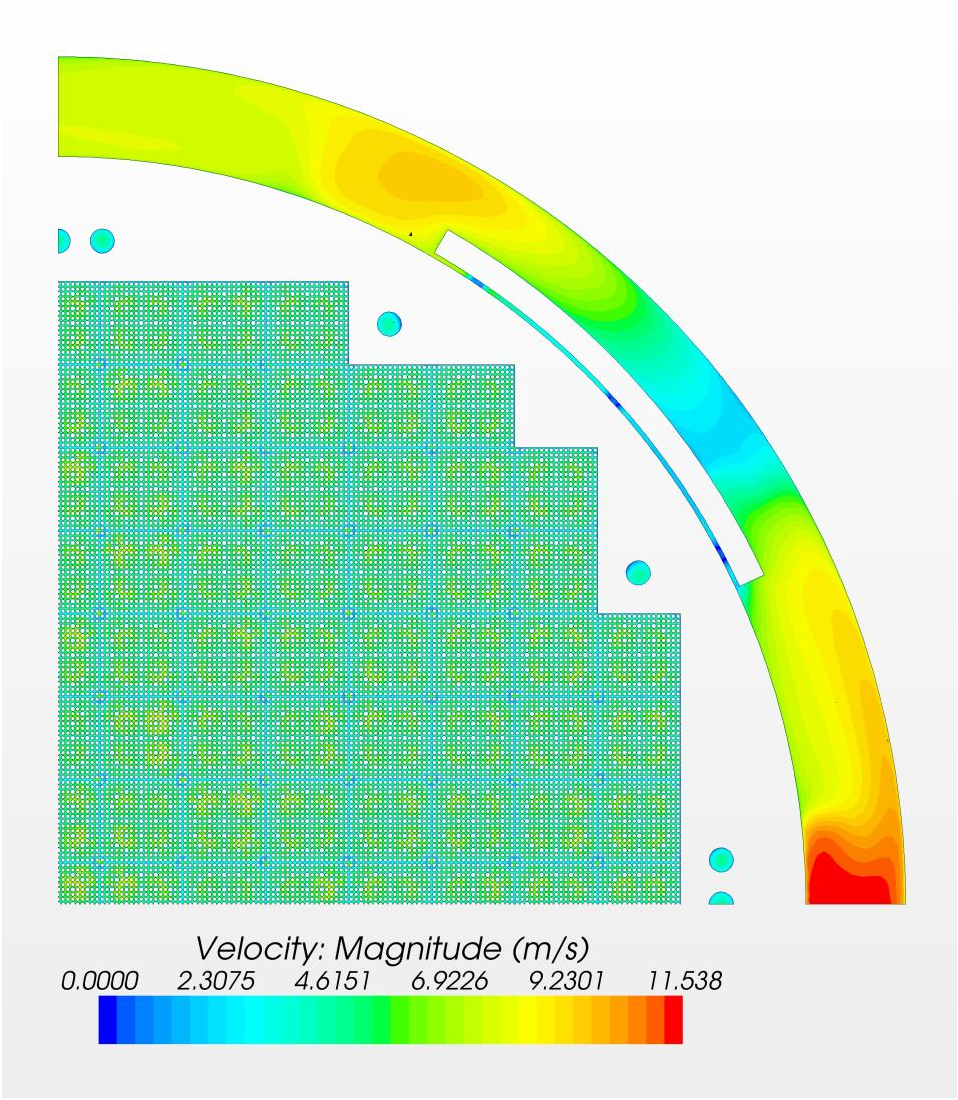
Modeling Zero Power and Hot Full Power Case

- Problems #5 & #9 modeled: 3D, pin-by-pin, DeCART solution
- Comparison with measured critical condition: 18 ppmB
- HFP and Depletion models are under development for comparison with operational data.





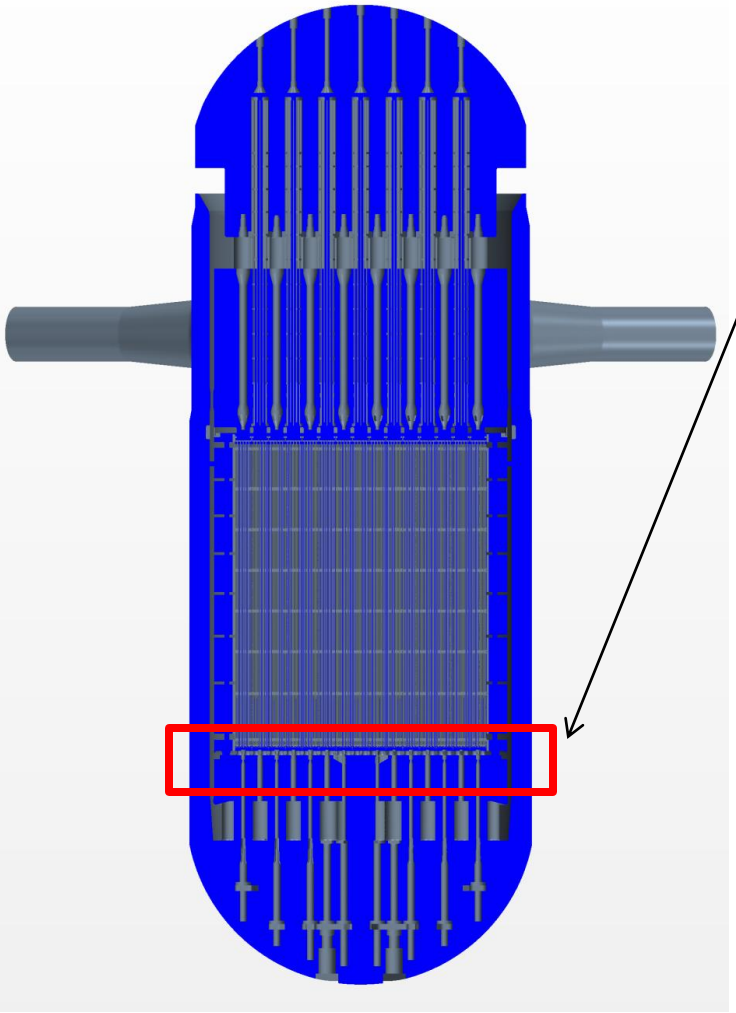
Models will be used to Identify Areas for Challenge Problems Risks and Provide B/Cs



Approach to Evaluate Challenge Problems

- Build CAD & CFD Models
- Run Coarse Mesh for ¼ Vessel
- Identify limiting areas for each challenge problem: CRUD, GTRF, PCI, FAD,DNB, LOCA, RIA, etc
- Perform more detailed analysis for each challenge problem using advanced tools
- Use for risk assessment to better understand margins and support power uprate feasibility studies

Near-Term Application of CFD Model – Modeling Alternative Flow Paths From Flow Blockage



- Industry council proposed problem ("pilot project")
- Model the effect of debris blockage using a porous media region at assembly inlet
- Alternate flow paths will be investigated
- Decay heat distribution will be applied to the fuel region.
- Peak temperature of the cladding and the fuel pellet will be calculated

Industry Involvement in CASL: Core Partners

- AMA Deputy Lead
- Industry Council Chair
- Requirements/Assessments
- Software contributions

- AMA Physical Reactor Applications Lead
- Operating Reactor Data
- Review CASL models
- Utility input and liaison

- AMA Deputy Lead/Challenge Problem Lead
- Chief Strategy Officer
- Challenge Problem Analysis
- Software contributions

Industry Involvement in CASL: Industry Council

Mission

Assure that CASL solutions are "used and useful" by industry, and that CASL provides effective leadership advancing the M&S state-of-the-art.

Objectives

- Early, continuous, and frequent interface and engagement of end-users and technology providers
- Critical review of CASL plans and products
- Optimum deployment and applications of periodic VERA releases
- Identification of strategic collaborations between industry and CASL FAs

Activities

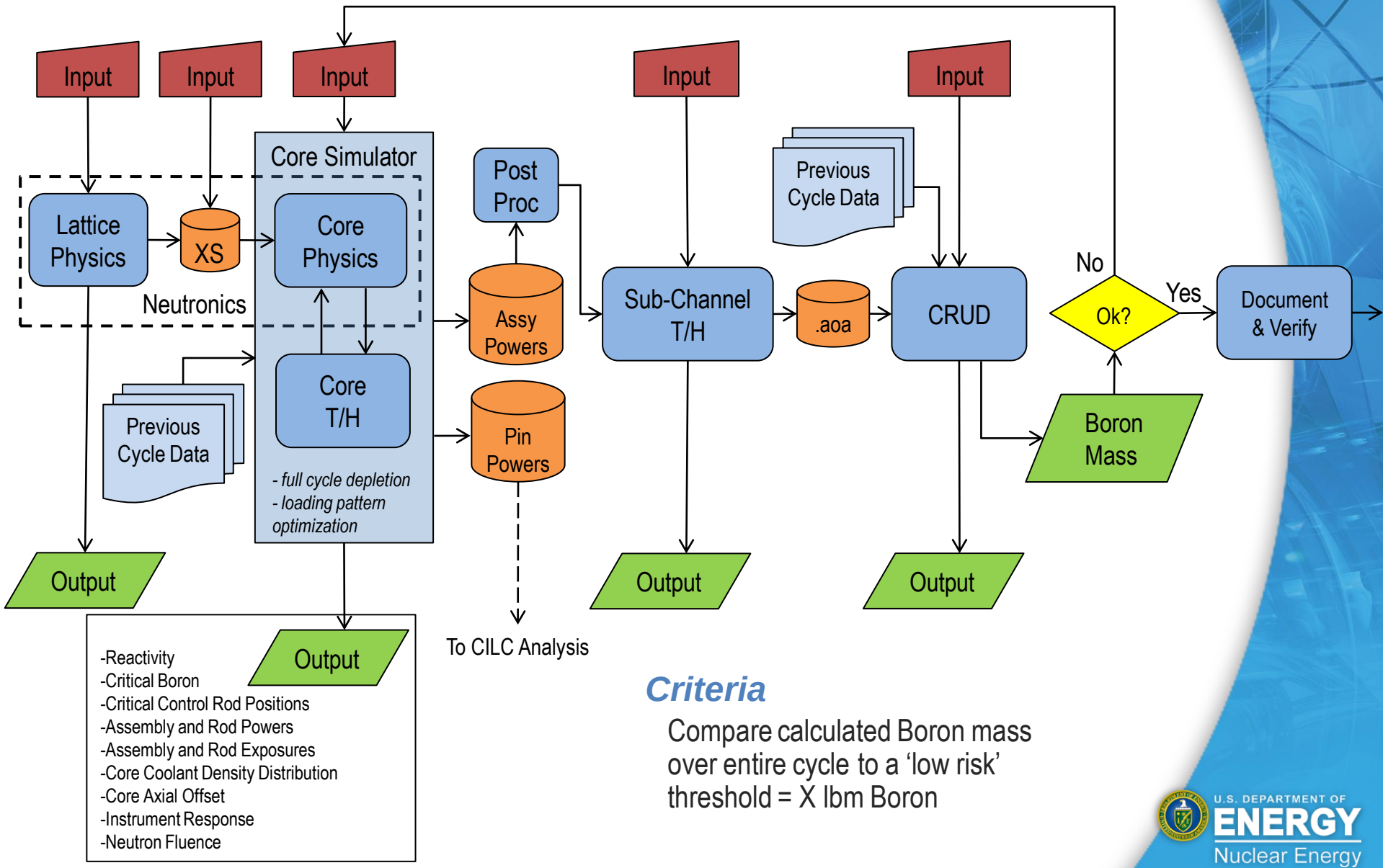
- Input on workflow/analysis approach to inform Virtual Reactor Development
- Identification of opportunities for early use ("pilot projects") of CASL capabilities to demonstrate value
- Review and comment on virtual reactor requirements and development

Industry Council Members

EPRI	ANSYS
Battelle	Bettis
	GSE Systems
AREVA	Rolls Royce
Westinghouse	Studsvik Scandpower
Global Nuclear Fuel	
	Cray Computing
Dominion	IBM
Duke Energy	NVIDIA
EDF	
TVA	DOE and BOD (ex-officio)

Chair: John Gaertner, EPRI

Industry Crud Induced Power Shift Risk Evaluation Workflow



Criteria

Compare calculated Boron mass over entire cycle to a 'low risk' threshold = X lbm Boron

Summary

- Development of operational reactor models are providing valuable experience in the development of complex models
  - Mesh development is significant challenge
  - Running codes on leadership class computers
  - Providing information to guide development of advanced capabilities
- Developing core-level challenge problem screening and risk assessment to identify regions for using more detailed capabilities
- Continued engagement and involvement of industry provides valuable experience and identifies useful application of capabilities